CHAPTER 8

MEDICAL ASPECTS OF CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL WARFARE

In this chapter we will discuss the history of chemical, biological, and radiological (CBR) warfare, and the recognition and treatment of CBR-produced conditions. We will also discuss the Medical Department's role in meeting the medical aspects of CBR defense, which includes protection from CBR hazards, mass casualty decontamination, decontamination stations, and supplies for decontamination. Table 8-1 provides a summary of CBR symptoms and treatments.

CHEMICAL WARFARE

LEARNING OBJECTIVE: *Select the appropriate treatment and decontamination procedure for chemical, biological, or radiological exposures.*

The use of chemical agents in warfare, frequently referred to as "gas warfare," is defined as the use of chemical agents in gaseous, solid, or liquid states to harass personnel, produce casualties, render areas impassable or untenable, or contaminate food and water. The chances of surviving a chemical attack are increased as knowledge of the nature of the agents and of the use of correct protective measures is increased.

HISTORY

The first large-scale use of chemical agents came in World War I when, in 1915, the Germans released chlorine gas against the Allied positions at Ypres, Belgium. Over 5,000 casualties resulted. There were other gas attacks by both combatant forces during World War I, and it is well documented that approximately one-third of all American casualties in this conflict were due to chemical agent attacks.

During the interval between World Wars I and II, each of the major powers continued to develop its capability for chemical warfare, in spite of a ban by the Geneva Treaty. In isolated cases in the late 1930s, toxic chemicals were used; however, they were not used during World War II. Nor were toxic chemicals authorized for use in Korea, Vietnam, or Desert Storm. Defoliants and riot-control agents were used with some degree of effectiveness in the jungles of Vietnam, in tunnel and perimeter-clearing operations.

DISPERSAL

Chemical agents are dispersed by modern weapons for strategic as well as tactical purposes. However, the areas of their use are limited by the range of the weapons or aircraft used by the combatant force.

A naval unit afloat finds itself in a unique situation with respect to defending against toxic chemical agents. Agents can be released as clouds of vapor or aerosol. These can envelope the exterior of a vessel and penetrate the hull of the ship. Extensive contamination can result from such an attack, and the ship must be decontaminated while the personnel manning it continue to eat, sleep, live, and fight on board.

To properly meet the medical needs of the ship, the medical officer or Hospital Corpsman on independent duty must organize the Medical Department well in advance of the actual threat of a chemical agent attack. All hands must be indoctrinated in the use of protective equipment and self-aid procedures, and close liaison and planning must be maintained with damage control personnel responsible for area decontamination.

SELF-PROTECTION AND TREATMENT

In a chemical attack, the first priority is to ensure your own survival so that you may then treat casualties. There are several items available to help you survive a chemical attack, and you should know how to use them. Along with protective clothing, there is a protective mask, which should be put on at the first indication of a chemical attack. The mask will filter out all known chemical agents from the air and allow you to work in a chemically contaminated area. A chemical agent on the skin can be removed effectively by using the M291 skin decontamination kit (fig. 8-1). The M291 skin decontamination kit replaces the M258A1 (fig. 8-2). Upon receipt of the M291, discontinue use of the M258A1.

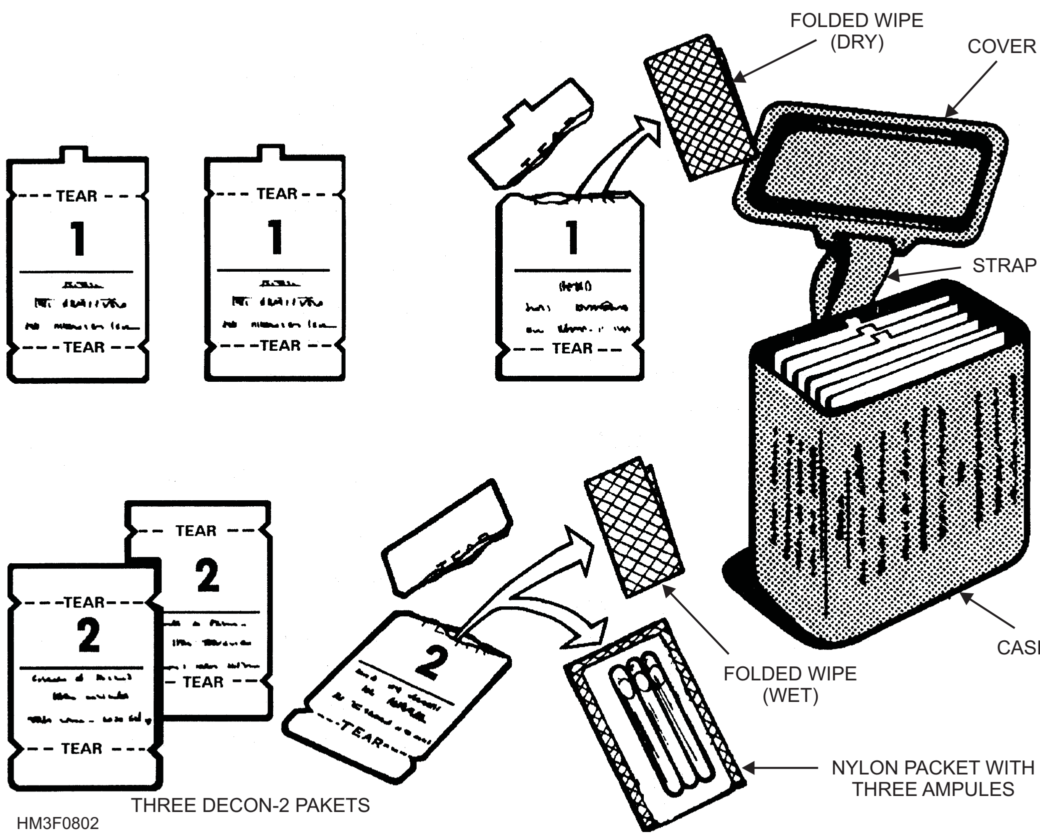
Table 8-1.—Summary of CBR Agents, Effects, and Treatment

TYPE OF AGENT	PHYSICAL CHARACTERISTICS	SYMPTOMS IN MAN	EFFECTS ON MAN	RATE OF ACTION	PERSONNEL DECONTAMINATION	TREATMENT
NERVE AGENT Tabun (GA) Sarin (GB) Soman (GD) VX	Colorless to light brown liquid Odorless to faint sweetish or fruity vapor Tasteless	Miosis, rhinorrhea, dimmed vision, salivation, nausea, abdominal cramping, increased bronchial secretions, dyspnea, pulmonary edema, headache, vertigo	Incapacitates; kills if high concentrations are inhaled or if contaminated skin is not decontaminated in time.	Very rapid with inhalation Slow through the skin.	None for aerosols or vapors. Flush eyes with water. Wash skin with soap and water, or use skin pad from M-13 kit; M-5 kit for VX.	Atropine IM or IV Artificial ventilation Oximes (2-PAM Cl) as adjunct to atropine
VESICANTS Mustard (HD) Nitrogen Mustard (HN) Lewisite (L) Phosgene Oxime (CX)	Odor of garlic or horseradish (HD) None to slightly fishy odor (HN) Fruity or odor or geranium (L) Disagreeable (CX) Colorless to dark brown liquid Vapors not usually visible	Lacrimation, eye pain, photophobia, cough, respiratory irritation, abdominal pain, nausea, vomiting, diarrhea Skin erythema and itching, headache	Generally nonlethal. Blisters skin, is destructive to upper respiratory tract; can cause temporary blindness. Some agents sting and form welts on skin, and others sear eyes.	Mustards: delayed effect Arsenicals and CX: rapid and intense	Remove contaminated clothing, wash skin with soap and water, or use M-5 ointment or M-13 kit.	Analgesics, sterile dressings, antibiotics, and treat for shock. For arsenicals, BAL in oil IM. For CX, sodium bicarbonate dressings.
BLOOD AGENTS Hydrocyanic acid (AC) Cyanogen chloride (CK)	Colorless gas Faint bitter almond odor (AC) Irritating odor (CK)	Increased respiration followed by dyspnea, nausea, vertigo, headache, convulsions, and coma	Inhibits cytochrome oxidase. Incapacitates; lethal if high concentrations are inhaled.	Rapid	None needed.	Amyl nitrate ampules Artificial respiration Sodium thiosulfate/sodium nitrite IV
CHOKING AGENTS Phosgene (CG)	Colorless gas odor of corn, grass, or new mown hay	Coughing, choking, tightness in chest, nausea, and headache	Lethal. Floods lungs, causes pulmonary edema	Immediate to 3 hours	None needed.	Rest, oxygen, antibiotics
VOMITING AGENTS Adamsite (DM)	Yellow or white to nonvisible gas Odor of burning fireworks	Pepperlike irritation of upper respiratory tract and eyes with lacrimation Uncontrolled sneezing and coughing and excessive salivation	Incapacitates. Local irritant.	Immediate	None needed.	Supportive Chloroform inhalation for symptomatic relief Physical exercise shortens duration and speeds recovery Recovery spontaneous
INCAPACITING AGENTS BZ	Odorless, colorless, tasteless	Unpredictable, irrational behavior; may be accompanied by coughing, nausea, vomiting, and headache. Dilation of pupils.	Temporarily incapacitates, mentally and physically. Anticholinergic. Psychotropic.	Delayed	Wash with soap and water.	Observation and physical restraint if indicated Physostigmine salicylate 2-3 mg IM every 1-2 hours for duration of symptoms
IRRITANTS Riot control agents CS, CN, CR, CA	Colorless to white vapor Pepperlike odor	Immediate lacrimation Coughing Skin irritation	Incapacitating. Local irritant.	Instantaneous	None needed.	Removal to fresh air
BIOLOGICAL AGENTS	Microscopic live organisms	Variable, depending on agent and resistance of victim	Lethal or incapacitating, depending on agent.	Delayed for days or longer	Wash with soap and water.	Variable, specific if agent is known Supportive
NUCLEAR BURST	Bright intense flash of light Heat, wind, shock wave Earth tremors	Temporary blindness Thermal burns Radiation burns Physical injuries	Blast destruction. Radiation sickness.	Immediate for blast Delayed for radiation	Wash with soap and water. Shower. Monitor.	Immediate decontamination Treatment of physical injuries Antibiotics for radiation exposure

HM3T0801

HM3F0801

Figure 8-1.—M291 skin decontamination kit.



HM3F0802

Figure 8-2.—M258A1 skin decontamination kit.

Chemical agents penetrate ordinary clothing rapidly. However, significant absorption through the skin requires a period of minutes. The effects of clothing penetration may be reduced by quickly removing the contaminated clothing and neutralizing the chemical agent on the skin by washing, blotting, or wiping it away.

Prompt decontamination (decon) of the skin is imperative. Decon of chemical agents on the skin within 1 minute after contamination is perhaps 10 times more effective than if decontamination is delayed 5 minutes. Detailed instructions on the use of skin decontamination kits can be found in the NAVMED P-5041, *Treatment of Chemical Agent Casualties and Conventional Military Chemical Injuries*, and in the kits themselves.

Finally, there are two types of antidote autoinjectors—atropine and 2-PAM Cl—for your own use if you become a nerve-agent casualty. The autoinjectors will be discussed later in this chapter. Familiarize yourself with your equipment. Know how it works before you need it.

DECONTAMINATION

The guiding principle in personnel decontamination is to avoid spreading contamination to clean areas and to manage casualties without aggravating other injuries.

Casualty Priorities

It will often be necessary to decide whether to handle the surgical condition or the chemical hazard first. If the situation and the condition of the casualty permit, decontamination should be carried out first. The longer the chemical remains on the body, the more severe will be the danger of spreading the chemical to other personnel and equipment.

The following order of priority for first aid and decontaminating casualties is recommended:

1. Control of massive hemorrhage
2. First aid for life-threatening shock and wounds
3. Decontamination of exposed skin and eyes
4. Removal of contaminated clothing and decontamination of body surfaces (if not in a toxic environment)
5. Adjustment of patient's mask, if mask is necessary
6. First aid in less severe shock and wounds

The basic steps in sorting and handling casualties are indicated in figure 8-3. This plan should be modified to fit specific needs.

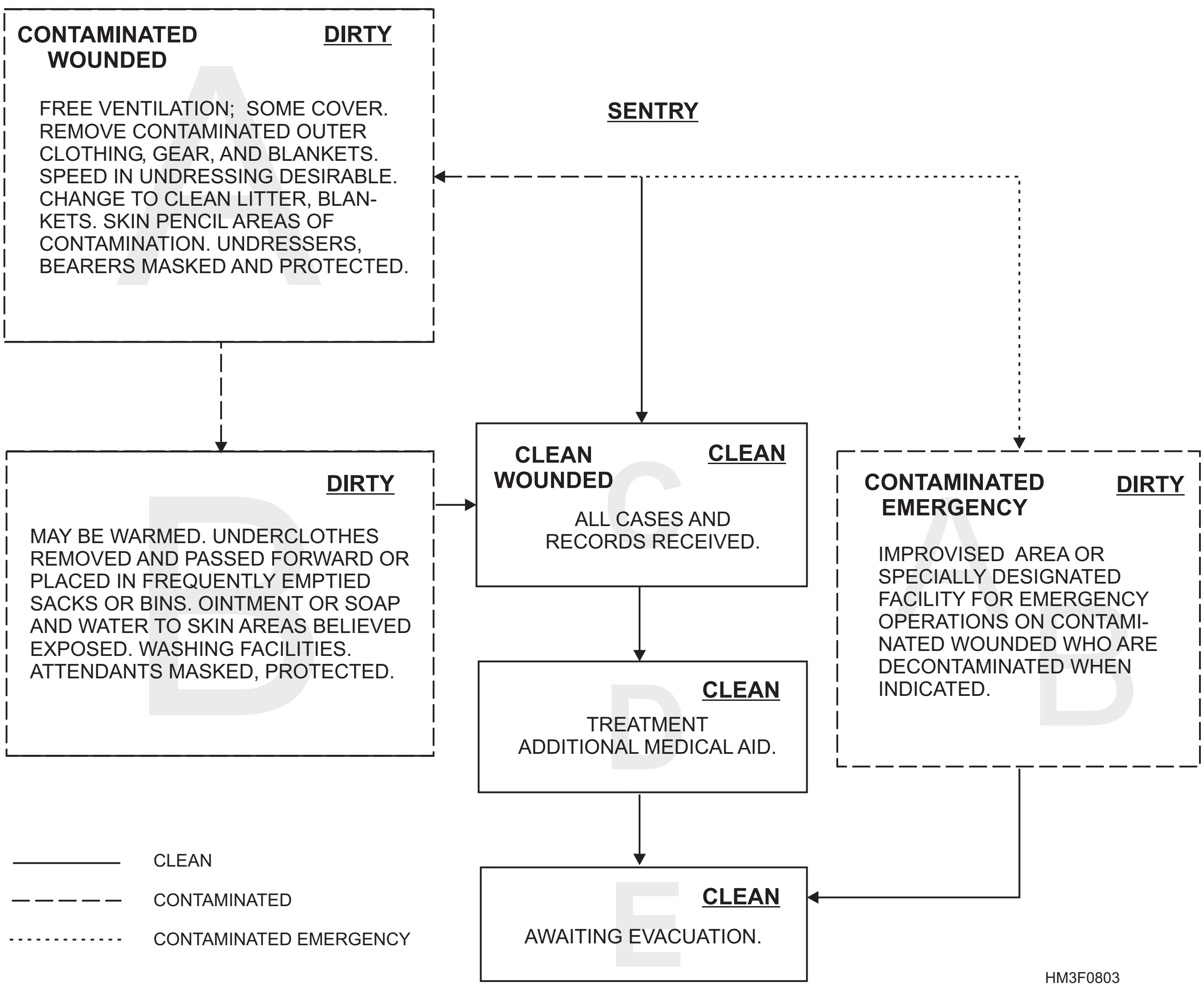


Figure 8-3.—Basic steps in sorting and handling casualties.

Decontamination Station Organization

In general, the decontamination station, or "dirty" area, receives casualties contaminated with a chemical agent. The arrangement of this area will vary with the site of the medical unit and the facilities available for decontamination.

Each ship will have a minimum of at least two decontamination stations, insofar as the hull design permits. The "dirty" areas should be topside or in some well-ventilated space. Personnel manning these areas should be provided with protective equipment.

In the "dirty" area, casualties will be decontaminated, undressed, showered, and passed along to clean areas. Both areas should be clearly marked as either "clean" or "contaminated," as appropriate. Decontamination kits, protective ointment, and an abundant supply of soap and water must be provided. In addition, standard first-aid items should be on hand. When possible, improvise supports (e.g., small boxes, blocks of wood, etc.) for stretchers to keep them raised off the deck.

Handling of Contaminated Casualties

The spread of contamination to uncontaminated personnel or to spaces not set aside to receive contamination must be avoided. Contaminated personnel, clothing, or equipment must be kept out of uncontaminated areas since the subsequent decontamination of such spaces is quite difficult. Contaminated clothing and gear must be placed in designated dump areas and, whenever practically possible, kept in metal cans with tightly fitting covers.

Supplies

The Medical Officer or Senior Medical Department Representative (SMDR) is responsible for maintaining adequate supplies for decontamination and treatment of CBR casualties. Medical decontamination supplies are supplied to ships on a personnel -strength basis, as listed in current Authorized Medical Allowance List (AMAL).

The decontamination supply cabinets will be kept locked, and the keys will be in custody of the Damage Control Assistant (DCA). Cabinets and chests will be stenciled with a red cross and marked "DECONTAMINATION MEDICAL SUPPLIES."

CHEMICAL AGENTS

Chemical agents are grouped under several classifications. The broadest classification we will use is based on the general effect produced (i.e., severe casualty, harassment, or incapacitation). Within each general group, there are further breakdowns, the most convenient of which (from a medical point of view) is the classification by physiologic effect. Chemical agents may also be classified as lethal or nonlethal. Nonlethal agents will not kill you. Lethal agents are those that result in a 10 percent or greater death rate among casualties. They are further classified as persistent or nonpersistent, depending on the length of time they retain their effectiveness after dissemination.

In the following paragraphs, we discuss the agents that produce the greatest number of fatalities and casualties among personnel who have been exposed to them.

Nerve Agents

Nerve agents produce their effect by interfering with normal transmission of nerve impulses in the parasympathetic autonomic nervous system. Physically, nerve agents are odorless, almost colorless liquids, varying greatly in viscosity and volatility. They are moderately soluble in water and fairly stable unless strong alkali or chlorinating compounds are added. They are very effective solvents, readily penetrating cloth either as a liquid or vapor. Other materials, including leather and wood, are fairly well penetrated. Butyl rubber and synthetics, such as polyesters, are much more resistant.

Pharmacologically, the nerve agents are cholinesterase inhibitors (interfering with normal transmission of nerve impulses in the parasympathetic autonomic nervous system). Their reaction with cholinesterase tends to be irreversible, and reaction time varies with the agent.

SIGNS AND SYMPTOMS OF EXPOSURE.— Nerve-agent intoxication can be readily identified by its characteristic signs and symptoms. If a vapor exposure has occurred, the pupils will constrict, usually to a pinpoint. If the exposure has been through the skin, there will be local muscular twitching where the agent was absorbed. Other symptoms will include rhinorrhea, dyspnea, diarrhea and vomiting, convulsions, hypersalivation, drowsiness, coma, and unconsciousness.

TREATMENT.—Specific therapy for nerve agent casualties is atropine, an acetylcholine blocker. **When exposed**, each member of the Navy and Marine Corps is issued three 2 mg autoinjectors of atropine and three 600 mg autoinjectors of 2-PAM Cl. **DO**

NOT give nerve agent antidotes for preventive purposes **before** contemplated exposure to a nerve agent.

The atropine autoinjector consists of a hard plastic tube containing 2 mg (0.7 ml) of atropine in solution for intramuscular injection. It has a pressure-activated coiled-spring mechanism that triggers the needle for injection of the antidote solution. These injectors are designed to be used by individuals on themselves when symptoms appear. For medical personnel, the required therapy is to continue to administer atropine at 15-minute intervals until a mild atropinization occurs. This can be noted by tachycardia and a dry mouth. Atropine alone will not relieve any respiratory muscle failure. Prolonged artificial respiration may be necessary to sustain life.

A second autoinjector containing oxime therapy (using pralidoxime chloride, or 2-PAM Cl) can also be used for regeneration of the blocked cholinesterase. Since 2-PAM Cl is contained in the kit of autoinjectors, additional oxime therapy is not generally medically recommended for those who have already received treatment by autoinjection. The 2-PAM Cl autoinjector is a hard plastic tube that, when activated, dispenses 600 mg of 2-PAM Cl (300 mg/ml) solution. It also has a pressure-activated coiled-spring mechanism identical to that in the atropine autoinjector.

Self-Aid.—If you experience the **mild** symptoms of nerve-agent poisoning, you should **IMMEDIATELY** hold your breath and put on your protective mask. Then, administer **one set** of (atropine and 2-PAM Cl) injections into your lateral thigh muscle or buttocks, as illustrated in figures 8-4 and 8-5. Position the needle end of the **atropine** injector against the injection site and apply firm, even pressure (not jabbing motion) to the injector until it pushes the needle into your thigh (or buttocks). Make sure you **do not** hit any buttons or other objects. Using a jabbing motion may result in an improper injection or injury to the thigh or buttocks.

Hold the **atropine** injector firmly in place for **at least 10 seconds.** The seconds can be estimated by counting "one thousand one, one thousand two," and so forth. Firm pressure automatically triggers the coiled mechanism and plunges the needle through the clothing into the muscle and at the same time injects the atropine antidote into the muscle tissue.

Next, inject yourself in the same manner with the **2-PAM Cl** injector, using the same procedure as you

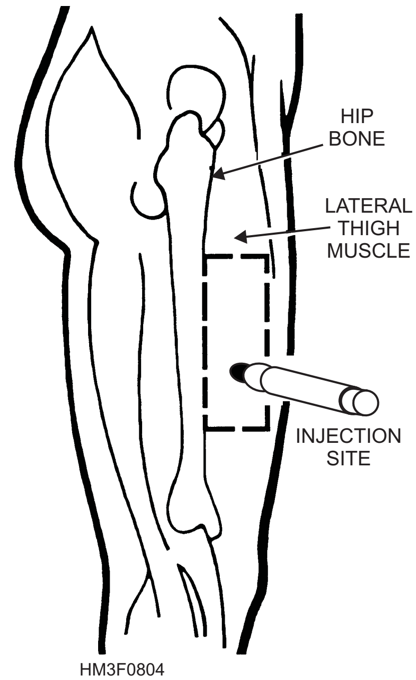


Figure 8-4.—Thigh injection site.

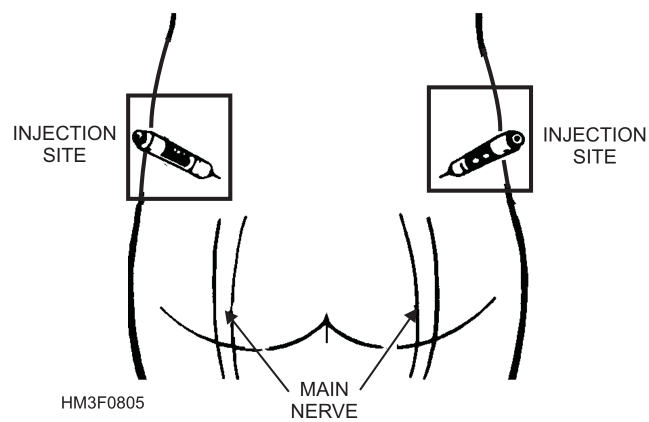


Figure 8-5.—Buttocks injection site.

did for the atropine. This will now complete one set of nerve-agent antidotes. Attach the used injectors to your clothing (fig. 8-6) (to indicate the number of injections you have already received).

After administering the first set of injections, wait 10 to 15 minutes (since it takes that long for the antidote to take effect) before administering a second set, if needed. If the symptoms have not disappeared within 10 to 15 minutes, give yourself the second set of injections. If the symptoms still persist after an additional 15 minutes, a third set of injections may be given by nonmedical personnel.

After administering each set of injections, you should decontaminate your skin, if necessary, and put on any remaining protective clothing.

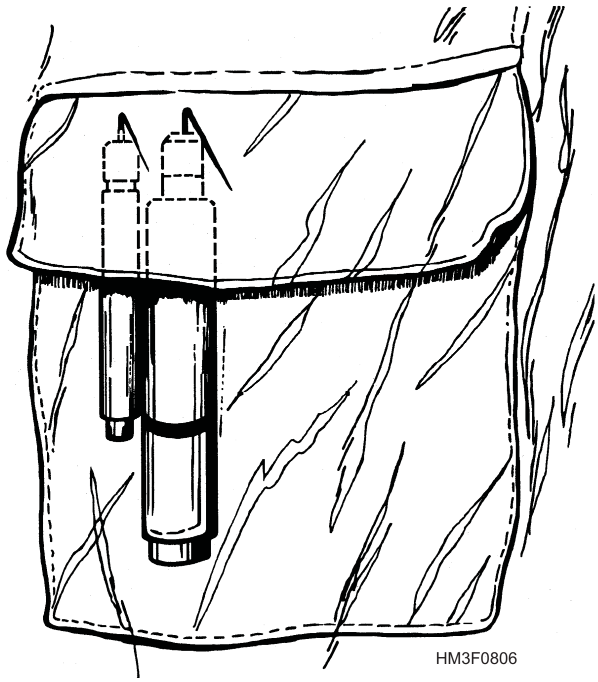


Figure 8-6.—One set of used autoinjectors attached to a pocket flap.

Buddy Aid.—If you encounter a service member suffering from severe signs of nerve-agent poisoning, you should provide the following aid:

- Mark the casualty, if necessary. Do not fasten the hood.
- Administer, in rapid succession, **three** sets of the nerve-agent antidotes. Follow the procedures for administration as described previously in the self-aid section.

  NOTE: Use the casualty's own autoinjectors when providing aid. Do not use your injectors on a casualty. If you do, you may not have any antidote available when needed for self-aid.

Blister Agents (Vesicants)

Blister agents, or vesicants, exert their primary action on the skin, producing large and painful blisters that are incapacitating. Although vesicants are classed as nonlethal, high doses can cause death.

Common blister agents include mustard (HD), nitrogen mustard (HN), and Lewisite (L). Each is chemically different and will cause significant specific symptoms. They are all similar in their physical characteristics and toxicology. Mustards are particularly insidious because they do not manifest their symptoms for several hours after exposure. They attack the eyes and respiratory tract as well as the skin. There is no effective therapy for mustard once its effects become visible. Treatment is largely supportive: to relieve itching and pain, and to prevent infection.

MUSTARD (HD) AND NITROGEN MUSTARD (HN).—HD and HN are oily, colorless or pale yellow liquids, sparingly soluble in water. HN is less volatile and more persistent than HD but has the same blistering qualities.

Signs and Symptoms of Exposure.—The eyes are the most vulnerable part of the body to mustard gas. Contamination insufficient to cause injury elsewhere may produce eye inflammation. Because the eye is the most sensitive part of the body, the first noticeable symptoms of mustard exposure will be pain and a gritting feeling in the eyes, accompanied by spastic blinking of the eyelids and photophobia. Vapor or liquid may burn any area of the skin, but the burns will be most severe in the warm, sweaty areas of the body: the armpits, groin, and on the face and neck. Blistering begins in about 12 hours but may be delayed for up to 48 hours. Inhalation of the gas is followed in a few hours by irritation of the throat, hoarseness, and a cough. Fever, moist rales, and dyspnea may develop. Brochopneumonia is a frequent complication. The primary cause of death is massive edema or mechanical pulmonary obstruction.

Treatment.—There is no specific antidotal treatment for mustard poisoning. Physically removing as much of the mustard as possible, as soon as possible, is the only effective method for mitigating symptoms before they appear. All other treatment is symptomatic, that is, the relief of pain and itching, and control of infection.

LEWISITE (L).—Lewisite is an **arsenical** (an arsenic-based compound). This blistering compound is a light- to dark-brown liquid that vaporizes slowly.

Signs and Symptoms of Exposure.—The vapors of arsenicals are so irritating that conscious persons are immediately warned by discomfort to put on the mask. No severe respiratory injuries are likely to occur, except in the wounded who are incapable of donning a mask. The respiratory symptoms are similar to those produced by mustard gas. While distilled mustard and nitrogen mustard cause no pain on the skin during absorption, Lewisite causes intense pain upon contact.

Treatment.—Immediately decontaminate the eyes by flushing with copious amounts of water to remove liquid agents and to prevent severe burns. Sodium sulfacetamide, 30 percent solution, may be used to combat eye infection within the first 24 hours after exposure. In severe cases, morphine may be given to relieve pain.

In cases of systemic involvement, British Anti-Lewisite (BAL), dimercaprol, is available in a peanut oil suspension for injection. BAL is a specific antiarsenical that combines with the heavy metal to form a water-soluble, nontoxic complex that is excreted. However, BAL is somewhat toxic, and an injection of more than 3 mg/kg will cause severe symptoms.

Aside from the use of dimercaprol for the systemic effects of arsenic, treatment is the same as for mustard lesions.

Blood Agents

Blood agents interfere with enzyme functions in the body, i.e., block oxygen transfer. Hydrocyanic acid (AC) and cyanogen chloride (CK) are cyanide-containing compounds commonly referred to as blood agents. These blood agents are chemicals that are in a gaseous state at normal temperatures and pressures. They are systemic poisons and casualty-producing agents that interfere with vital enzyme systems of the body. They can cause death in a very short time after exposure by interfering with oxygen transfer in the blood. Although very deadly, they are nonpersistent agents.

SIGNS AND SYMPTOMS OF EXPOSURE.— These vary with concentration and duration of exposure. Typically, either death or recovery takes place rapidly. After exposure to high concentrations of the gas, there is a forceful increase in the depth of respiration for a few seconds, violent convulsions after 20 to 30 seconds, and respiratory failure with cessation of heart action within a few minutes.

TREATMENT.—There are two suggested antidotes in the treatment of cyanides: amyl nitrite in crush ampules (provided as first aid) and intravenous sodium thiosulfate solution.

In an attack, if you notice sudden stimulation of breathing or an almond-like odor, hold your breath and don your mask immediately. In treating a victim, upon notification by competent authority that there are no blood agents remaining in the atmosphere, crush two ampules of amyl nitrite in the hollow of your hand and hold it close to the victim's nose. You may repeat this procedure every few minutes until eight ampules have been used. If the atmosphere is contaminated and the victim must remain masked, insert the crushed ampules into the mask under the face plate.

Whether amyl nitrite is used or not, sodium thiosulfate therapy is required after the initial lifesaving measures. The required dose is 100 to 200 mg/kg, given intravenously over a 9-minute period.

The key to successful cyanide therapy is speed; cyanide acts rapidly on an essential enzyme system. The antidotes act rapidly to reverse this action. If the specific antidote and artificial respiration are given soon enough, the chance of survival is greatly enhanced.

Choking or Lung Agents

The toxicity of lung agents is due to their effect on lung tissues; they cause extensive damage to alveolar tissue, resulting in severe pulmonary edema. This group includes phosgene (CG) and chlorine (Cl), as well as chloropicrin and diphosgene. However, CG is most likely to be encountered, and its toxic action is representative of the group.

Phosgene is a colorless gas with a distinctive odor similar to that of new-mown hay or freshly cut grass. Unfortunately, even at minimal concentrations in the air (i.e., below the threshold of olfactory perception), CG can cause damage to the eyes and throat. Generally speaking, CG does not represent a hazard of long duration; therefore, an individual exposed to a casualty-producing amount should be able to smell it.

SIGNS AND SYMPTOMS OF EXPOSURE.— There may be watering of the eyes, coughing, and a feeling of tightness in the chest. More often, however, there will be no symptoms for 2 to 6 hours after exposure. Latent symptoms are rapid, shallow, and labored breathing; painful cough; cyanosis; frothy sputum; clammy skin; rapid, feeble pulse; and low blood pressure. Shock may develop, followed by death.

TREATMENT.—Once symptoms appear, complete bed rest is mandatory. Keep victims with lung edema only moderately warm, and treat the resulting anoxia with oxygen. Because no specific treatment for CG poisoning is known, treatment has to be symptomatic.

Incapacitating Agents

Incapacitating agents, which are mainly comprised of psychochemicals, produce mental confusion and an inability to function intelligently.

The psychochemicals temporarily prevent an individual from carrying out assigned actions. These agents may be administered by contaminating food or water, or they may be released as aerosols. The following are characteristics of the incapacitants:

- High potency (i.e., an extremely low dose is effective) and logistic feasibility
- Effects produced mainly by altering or disrupting the higher regulatory activity of the central nervous system
- Duration of action comprising hours or days, rather than momentary or transient action
- No permanent injury produced

SIGNS AND SYMPTOMS OF EXPOSURE.— The first symptoms appear in 30 minutes to several hours and may persist for several days. Abnormal, inappropriate behavior may be the only sign of intoxication. Those affected may make irrational statements and have delusions or hallucinations. In some instances, the victim may complain of dizziness, muscular incoordination, dry mouth, and difficulty in swallowing.

The standard incapacitant in the United States is 3-quinuclidinyl benzilate (BZ), a cholinergic blocking agent, which is effective in producing delirium that may last several days. In small doses it will cause an increase in heart rate, pupil size, and skin temperature, as well as drowsiness, dry skin, and a decrease in alertness. As the dose is increased to higher levels, there is a progressive deterioration of mental capability, ending in stupor.

TREATMENT.—The first aid is to prevent victims from injuring themselves and others during the toxic psychosis. Generally, there is no specific therapy for this type intoxication. However, with BZ and other agents in the class of compounds known as glycolates, physostigmine is the drug treatment of choice. It is not effective during the first 4 hours following exposure; after that, it is very effective as long as treatment is continued. However, treatment does not shorten the duration of BZ intoxication, and premature discontinuation of therapy will result in relapse.

Riot-Control/Harassment Agents

"Riot-control agents" is the collective term used to describe a collection of chemical compounds, all having similar characteristics which, though relatively nontoxic, produce an immediate but temporary effect in very low concentrations. These agents are used to harass enemy personnel or to discourage riot actions. Generally, patients require no therapy; removal from the environment is sufficient to effect recovery in a short time.

There are two classes of riot-control/harassment agents: lacrimators and vomiting agents.

LACRIMATORS.—Lacrimators (or tear gases) are essentially local irritants that act primarily on the eyes. In high concentrations, they also irritate the respiratory tract and the skin. The principal agents used are chloracetophenone (CN) and orthochlorobenzilidine malanonitrile (CS). Although CS is basically a lacrimator, it is considerably more potent than CN and causes more severe respiratory symptoms. CN is the standard training agent and is the tear gas most commonly encountered because it is not as potent. CS is more widely used by the military as a riot-control agent.

Protection against all tear agents is provided by protective masks and ordinary field clothing secured at the neck, wrists, and ankles. Personnel handling CS should wear rubber gloves for additional protection.

Signs and Symptoms of Exposure.— Lacrimators produce intense pain in the eyes with excessive tearing. The symptoms following the most severe exposure to vapors seldom last over 2 hours. After moderate exposure, they last only a few minutes.

Treatment.—First aid for lacrimators is generally not necessary. Exposure to fresh air and letting wind blow into wide open eyes, held open if necessary, is sufficient for recovery in a short time. Any chest discomfort after CS exposure can be relieved by talking.

An important point to remember is that this material adheres tenaciously to clothing, and a change of clothing may be necessary. Do not forget the hair (both head and facial) as a potential source of recontamination.

VOMITING AGENTS.—Vomiting agents comprise the second class of agents in the riot-control category. The principal agents of this group are diphenylaminochloroarsine (Adamsite (DM)), diphenylchloroarsine (DA), and diphenylcyanoarsine (DC). They are used as training and riot-control agents. They are dispersed as aerosols and produce their effects by inhalation or by direct action on the eyes. All of these agents have similar properties and pathology.

Signs and Symptoms of Exposure.—Vomiting agents produce a strong pepper-like irritation in the upper respiratory tract, with irritation of the eyes and lacrimation. They cause violent uncontrollable sneezing, coughing, nausea, vomiting, and a general feeling of malaise. Inhalation causes a burning sensation in the nose and throat, hypersalivation, and rhinorrhea. The sinuses fill rapidly and cause a violent frontal headache.

Treatment.—It is of the utmost importance that the mask be worn in spite of coughing, sneezing, salivation, and nausea. If the mask is put on following exposure, symptoms will increase for several minutes in spite of adequate protection. As a consequence, victims may believe the mask is ineffective and remove it, further exposing themselves. While the mask must be worn, it may be lifted from the face briefly, if necessary, to permit vomiting or to drain saliva from the face piece. Carry on duties as vigorously as possible. This will help to lessen and shorten the symptoms. Combat duties usually can be performed in spite of the effects of vomiting agents if an individual is motivated.

First aid consists of washing the skin and rinsing the eyes and mouth with water. A mild analgesic may be given to relieve headache. Recovery is usually spontaneous and complete within 1 to 3 hours.

SCREENING SMOKES.—Screening smokes fit in with riot-control agents. Their primary use is to obscure vision and to hide targets or areas. When used for this purpose outdoors, they are not generally considered toxic. However, exposure to heavy smoke concentration for extended periods, particularly near the source, may cause illness or death. Under no circumstances should smoke munitions be activated indoors or in closed compartments.

Symptomatic treatment of medical problems or discomfort resulting from exposure to screening smokes will generally suffice.

WHITE PHOSPHORUS.—White phosphorus (WP) is a pale, waxy solid that ignites spontaneously on contact with air to give a hot, dense, white smoke composed of phosphorus pentoxide particles. While field concentrations of the smoke may cause temporary irritation to the eyes, nose, and throat, casualties from the smoke have not occurred in combat operations. No treatment is necessary, and spontaneous recovery is rapid once the patient is removed from the WP source.

White phosphorus smoke not only creates an obscuring smoke, but it also has a secondary effect upon personnel if it contacts the skin. When burning particles of WP embed in the skin, they must be covered with water, a wet cloth, or mud. A freshly mixed 0.5 percent solution of copper sulfate (which produces an airproof black coating of copper phosphide) may be used as a rinse but must not be used as a dressing. The phosphorus particles must be removed surgically.

BIOLOGICAL WARFARE

Epidemics arising from natural causes have plagued military forces for centuries and in many instances have determined the outcome of campaigns. Recognition of this drain on personnel undoubtedly has led to attempts to produce illness in epidemic proportions, through pollution of water and food supplies as well as through other means. The dissemination of disease-producing organisms has never been employed on any significant scale as a weapon of war.

HISTORY

Biological warfare has become a very real possibility since World War II because of the advance of knowledge in the various biological science fields. Many countries have indulged in research on the use of microorganisms as a weapon of war, and in the hands of an unscrupulous enemy, antianimal and antiplant agents could be powerful instruments of war, reducing or destroying a nation's food supply. In this chapter, however, we are concerned only with agents that would be effective against populations. Although their effectiveness has never been established by actual use in war, they are considered to have grave military capabilities.

DISPERSAL

Biological warfare has certain aspects in common with chemical warfare in that biological agents can be dispersed in the air and travel downwind in the same manner as a gas cloud. These agents may be inhaled unless a protective mask is worn, and they may cause disability or death. They are capable of contaminating clothing, equipment, food, and water supplies. Some types of agents may persist in the target area for considerable periods of time.

Biological agents, unlike most war gases or vapors, cannot be detected by the physical senses or by chemical detectors. Their presence or identity can be determined only by laboratory examination of air samples or contaminated objects. The time between exposure and onset of disease symptoms will usually be a matter of days rather than hours, as is the case with most chemical agents. Though they may be exposed to the same dosage of biological agent, not all personnel will be affected the same way. Some may become seriously ill, while others may have a very mild attack. Still others may escape the disease entirely.

PROTECTION

In this section, we will discuss both individual and group protection, as well as the methods of protecting food and water supplies.

Individual Protection

The natural resistance of the body and its maintenance in the best possible physical condition constitute important lines of defense against biological agents. Immunity and good health alone, however, cannot be expected to triumph over massive onslaughts of biological agents. These agents may have been tailored to create varying degrees of incapacitation, including death. To reduce the effectiveness of such attacks, the military provides protective equipment and a series of protocols to its members. In general, these measures closely parallel those provided for defense against chemical attack.

PORTALS OF ENTRY.—Inhalation of airborne organisms is considered the greatest potential hazard in biological warfare. The protective mask is an important piece of defensive equipment. A mask that is in good condition and has been properly fitted will greatly reduce the possibility of your inhaling infectious material. Since you cannot detect the presence of biological agents, the use of the mask and other protective equipment will depend upon early warning.

To produce disease, biological agents must gain entrance into the body. A concentration of biological agents on the skin might, in time, be transferred to a portal of entry. Any type of clothing will provide some protection by reducing the quantity of agents coming in contact with the skin. The degree of protection afforded is dependent upon how well the fabric stops penetration and the number of layers of clothing being worn. Since this protective effect is due to the mechanical filtering or screening action of the cloth, it is important that shirt and jacket collars be fastened. Sleeves should be rolled down and cuffs buttoned, trouser cuffs stuffed inside tops of boots or socks, and all other garment openings tied or otherwise secured. Following this procedure will minimize the entry of airborne organisms and reduce the risk of bodily contact with biological agents that may be present on the surface of the ground or in the air.

EQUIPMENT AND ACTION.—Military headgear helps safeguard the hair from heavy contamination, and ordinary gloves or mittens provide protection for the hands. The type of clothing issued for protection against chemical agents is impregnated with an impermeable barrier and provides a higher degree of protection than the ordinary uniform. Whenever it is available, it should be used.

Upon notification of an attack with biological agents, or before entering an area known to be contaminated by them, the following steps should be taken:

1. Put on protective mask and check it for correct fit.
2. Button clothing. Tie clothing at wrists and ankles with string or extra shoelaces. Put on special protective clothing, if available.
3. Put on gloves, if available.
4. While in the contaminated area, maintain the provisions outlined above.

Upon leaving the area, proceed with decontamination measures to the extent the situation permits.

Group Protection

In biological as well as chemical and radiological warfare, a tightly constructed shelter offers great protection. The shelter must be pressurized to prevent entrance of the microorganisms. Pressurization is accomplished by introducing filtered air into the shelter. If the shelter is reasonably tight, this incoming air will force exhausted and/or contaminated air outward. Nonpressurized buildings, shelters, or field fortifications provide only limited protection from aerosols. Eventually, microorganisms will penetrate through cracks, creating a respiratory hazard requiring the use of a protective mask. As in the case of other protective equipment, the sooner a shelter is used following contamination, the more effective the shelter will be in arresting or staying in contact with biological agents.

Protection of Food and Water

Food and water supplies are especially susceptible to deliberate contamination. Civilian supplies— which all too frequently do not receive careful supervision and protection—must always be suspected of accidental or deliberate contamination. It should also be emphasized that water is not necessarily pure just because it comes from a faucet. In some countries pure water is the exception rather than the rule. The safest rule is to consume only food and drinks received from military sources. Procedures for protection of the water supply and routines for inspection and decontamination are well defined in the military and, if diligently observed, will protect from deliberate contamination.

FOOD.—In the event of a known or suspected biological attack, all exposed or unpackaged foods not in critical supply should be destroyed. In most instances, food can be rendered safe for consumption by application of moist-heat cooking procedures. In some instances, deep-fat cooking is adequate. Some foods, however, cannot be sterilized because the treatment would render them unacceptable for consumption.

WATER.—Chlorination is by far the almost universal method of purifying water, and it destroys most of the biological agents. Boiling may be required to ensure proper decontamination in exceptional cases.

The military establishes water points in the field whenever possible. The equipment location at these points provides for filtration as well as chlorination and, when properly operated, is effective in removing organisms that produce disease. Some biological agents cannot be destroyed by normal water-purification techniques. When biological agents are known to have been used, all drinking water must be boiled. In the preparation of water for large numbers, the boiling procedure should be supervised. Water boiling may, of necessity, become an individual responsibility and may be so directed.

For small groups of people, the Lyster bag is provided as a suitable container for the storage of water that has already been treated. Water that has not been made potable previously is purified in the Lyster bag by means of chemicals. Water purification procedures are discussed in detail in the *Preventive Medicine Manual*, NAVMED P-5010.

DECONTAMINATION

Personal decontamination following actual or suspected exposure to biological agents will depend upon the existing tactical situation and the facilities available. If the situation permits, contaminated clothing should be carefully removed and the body washed thoroughly with soap and water before donning fresh clothing. Specific attention should be given to decontamination and treatment of skin lesions.

Normally, each individual is responsible for his own decontamination. If a person is physically unable to decontaminate himself, this process has to be performed by other available personnel. Since illness resulting from exposure to biological warfare may be delayed because of the incubation period, decontamination may occur before the individual becomes ill. Decontamination of the wounded is the responsibility of Medical Department personnel. When the situation and the condition of the casualty permit, decontamination should come first. However, massive hemorrhage, asphyxia, or other life-endangering conditions naturally receive priority.

In general, all candidates for decontamination should first have all exposed areas thoroughly washed with soap and large amounts of water, the mask adjusted, and all contaminated clothing removed. The casualty may then be moved to a clean area where the wounds can be treated.

Decontamination procedures are the same as those used for casualties of chemical warfare.

RADIOLOGICAL WARFARE

Radiological—the "R" in CBR—warfare is more frequently referred to as nuclear warfare. The principles of treatment of casualties, as developed from previous experiences in conventional warfare, are applicable in the treatment of casualties produced by radiological warfare. With the exception of ionizing radiation effects, the type of injuries produced in nuclear warfare are similar to those of conventional warfare. Standardized techniques of treatment must be adopted for all types of casualties so the greatest number of patients can receive maximum medical care in the shortest period of time with the greatest economy of medical personnel and equipment.

HISTORY

The death and devastation evidenced by the first and only use of nuclear power in wartime (in Hiroshima and Nagasaki, Japan, at the end of World War II) has, to date, kept it from being used again. Although a nuclear nonproliferation treaty has been signed by most of the major powers, nuclear weaponry is still a part of the arsenal of many countries of the world, some of which, if given the opportunity and excuse, would not hesitate to employ it to achieve victory at any cost.

History has shown that nuclear warfare is capable of producing a large disparity between the available medical care and the number of casualties requiring care. The capabilities of medical facilities and personnel must be surveyed to determine how and where they can best be utilized. Both professional and nonprofessional personnel must be trained in additional skills related as far as possible to their primary duties. Within medical organizations, efficiency will depend upon controlled patient flow, adequate supplies, and continuing essential housekeeping and administrative functions. To meet the requirements, it is essential that all medical service personnel be trained to assume some additional responsibilities.

EXPOSURE FACTORS

Teams entering contaminated areas to either remove casualties or work in decontamination stations have two major concerns. The first concern is the prevention of their own contamination, and the second is the prevention or reduction of radioactive exposure. Contamination can be avoided by decontaminating patients and equipment before handling, wearing appropriate protective clothing and equipment, avoiding highly contaminated areas, and strictly observing personal decontamination procedures. Exposure to radiation should also be avoided or minimized. Alpha and beta particles and gamma rays are emitted from radioactive contaminants and present a direct risk to the health and safety of personnel in the contaminated area. This risk can be avoided (or at least minimized) by following some simple guidelines and using common sense. Time, distance, and shielding are the major elements that guide actions to avoid exposure.

Time

Radioactive decay and the decomposition of fallout products progress rapidly in the early hours after a nuclear blast, and the hazards to rescue workers can be reduced considerably if operations can be delayed until natural decay has reduced the level of radioactivity. Use teams trained in the use of survey instruments since they will determine the intensity of radiation and mark perimeters of danger zones.

Limiting the time of exposure is essential if total avoidance is not possible. Rotating personnel entering an exposure risk area, planning actions to minimize time in the area, and prompt decontamination reduce the total time the individual is exposed, thereby reducing the dose of radiation absorbed by the body.

Distance

Both radioactive particles and electromagnetic waves (gamma rays) lose energy and consequently lose their ability to harm tissue as they travel away from their source. Therefore, the farther one is from the source, the more the danger of an exposure is minimized.

Shielding

Shielding is an essential component in preventing radiation exposure. Alpha and beta particles have very little penetrating power, and the intact skin forms an adequate barrier in most cases. Gamma radiation has much greater penetrating power and presents the greatest risk of exposure and damage to tissue.

Lead is the most effective shielding material. Wood, concrete, other metals, and heavy clothing will somewhat reduce the amount of gamma radiation that reaches the body. Most particle exposure is the result of inhalation or ingestion, although radiation particles may enter the body through burned, abraded or lacerated skin. In avoiding particle exposure, full personnel-protective clothing and a protective mask with hood provides the best protection. The protective mask and foul-weather gear will provide lesser but adequate protection. In cases where no protective breathing devices are available, some protection is afforded by breathing through a folded towel, handkerchief, or several surgical masks. Avoid hand-to-mouth contact, eating, or smoking in contaminated areas.

EFFECTS ON PERSONNEL

The injuries to personnel resulting from a nuclear explosion are divided into three broad classes: blast and shock injuries, burns, and ionizing radiation effects.

Apart from the ionizing radiation effects, most of the injuries suffered in a nuclear weapon explosion will not differ greatly from those caused by ordinary high explosives and incendiary bombs. An important aspect of injuries in nuclear explosions is the "combined effect," that is, a combination of all three types of injuries. For example, a person within the effective range of a weapon may suffer blast injury, burns, and also from the effects of nuclear radiation. In this respect, radiation injury may be a complicating factor, since it is combined with injuries due to other sources.

Blast and Shock Wave Injuries

Injuries caused by blast can be divided into primary (direct) blast injuries and secondary (indirect) blast injuries.

Primary blast injuries are those that result from the direct action of the air shock wave on the human body. These injuries will be confined to a zone where fatal secondary blast and thermal damage may be anticipated. Therefore, most surviving casualties will not have the severe injuries that result from the direct compressive effects of the blast wave.

Secondary blast injuries are caused by collapsing buildings and by timber and other debris flung about by the blast. Persons may also be hurled against stationary objects or thrown to the ground by the high winds accompanying the explosions. The injuries sustained are thus similar to those due to a mechanical accident: bruises, concussions, cuts, fractures, and internal injuries.

At sea, the shock wave accompanying an underwater burst will produce various "mechanical" injuries. These injuries will resemble those caused aboard ship by more conventional underwater weapons, such as noncontact mines and depth charges. Instead of being localized, however, they will extend over the entire vessel.

Equipment, furniture, gas cylinders, boxes, and similar gear, when not well secured, can act as missiles and cause many injuries.

Burn Injuries

A weapon detonated as an air burst may produce more burn casualties than blast or ionizing radiation casualties. Burns due to a nuclear explosion can also be divided into two classes: direct and indirect burns. **Direct burns** (usually called **flash** burns) are the result of thermal (infrared) radiation emanating from a nuclear explosion, while **indirect burns** result from fires caused by the explosion. Biologically, they are similar to any other burn and are treated in the same manner.

Since all radiation travels in a straight line from its source, flash burns are sharply limited to those areas of the skin facing the center of the explosion. Furthermore, clothing will protect the skin to some degree unless the individual is so close to the center of the explosion that the cloth is ignited spontaneously by heat. Although light colors will absorb heat to a lesser degree than dark colors, the thickness, air layers, and types of clothing (wool is better than cotton) are far more important for protection than the color of the material.

Eye Burns

In addition to injuries to the skin, the eyes may also be affected by thermal radiation. If people are looking in the general direction of a nuclear detonation, they may be flash blinded. This blindness may persist for 20 to 30 minutes.

A second and very serious type of eye injury may also occur. If people are looking directly at the fireball of a nuclear explosion, they may receive a retinal flash burn similar to the burn that occurs on exposed skin. Unfortunately, when the burn heals, the destroyed retinal tissue is replaced by scar tissue that has no light-perception capability, and the victims will have scotomas, blind or partially blind areas in the visual field. In severe cases, the net result may be permanent blindness. The effective range for eye injuries from the flash may extend for many miles when a weapon is detonated as an air burst. This effective range is far greater at night when the pupils are dilated, permitting a greater amount of light to enter the eye.

Radiation Injuries

Radioactivity may be defined as the spontaneous and instantaneous decomposition of the nucleus of an unstable atom with the accompanying emission of a particle, a gamma ray, or both. The actual particles and rays involved in the production of radiation injuries are the alpha and beta particles, the neutron, and the gamma ray. These particles and rays produce their effect by ionizing the chemical compounds that make up the living cell. If enough of these particles or rays disrupt a sufficient number of molecules within the cell, the cell will not be able to carry on its normal functions and will die.

ALPHA.—Alpha particles are emitted from the nucleus of some radioactive elements. Alpha particles produce a high degree of ionization when passing through air or tissue. Also, due to their large size and electrical charge, they are rapidly stopped or absorbed by a few inches of air, a sheet of paper, or the superficial layers of skin. Therefore, alpha particles do not constitute a major external radiation hazard. However, because of their great ionization power, they constitute a serious hazard when taken into the body through ingestion, inhalation, or an open wound.

BETA.—Beta particles are electrons of nuclear origin. The penetration ability of a beta particle is greater than an alpha particle, but it will only penetrate a few millimeters of tissue and will most probably be shielded out by clothing. Therefore, beta particles, like alpha particles, do not constitute a serious external hazard; however, like alpha particles, they do constitute a serious internal hazard.

NEUTRONS.—Neutrons are emitted from the nucleus of the atom. Their travel is therefore unaffected by the electromagnetic fields of other atoms. The neutron is a penetrating radiation which interacts in billiard-ball fashion with the nucleus of small atoms like hydrogen. This interaction produces high-energy, heavy-ionizing particles that can cause significant biological damage similar to that produced by alpha particles.

GAMMA RAYS.—Gamma rays are electromagnetic waves. Biologically, gamma rays are identical to x-rays of the same energy and frequency. Because they possess no mass or electrical charge, they are the most penetrating form of radiation. Gamma rays produce their effects mainly by knocking orbital electrons out of their path—thereby ionizing the atom so affected—and imparting to the ejected electron. Neutrons and gamma rays are emitted at the time of the nuclear explosion, along with light. Gamma rays and beta particles are present in nuclear fallout along with alpha particles from unfissioned nuclear material. Neutrons and gamma rays are an important medical consideration in a nuclear explosion since their range is great enough to produce biologic damage, either alone or in conjunction with blast and thermal injuries.

PROTECTION AND TREATMENT

Preparations for the protection and treatment of projected casualties of a nuclear attack must be made in advance of any such assault.

Action before Nuclear Explosion

If there is sufficient warning in advance of an attack, head as quickly as possible for the best shelter available. This is the same procedure as would be used during an attack by ordinary, high-explosive bombs. At the sound of the alarm, get your protective mask ready. Proceed to your station or to a shelter, as ordered. If you are ordered to a shelter, remain there until the "all clear" signal is given.

In the absence of specially constructed shelters during a nuclear explosion ashore, you can get some protection in a foxhole, a dugout, or on the lowest floor or basement of a reinforced concrete or steel-framed building. Generally, the safest place is in the basement near walls. The next best place is on the lowest floor in an interior room, passageway, or hall, away from the windows and, if possible, near a supporting column. Avoid wooden buildings when possible. If you have no choice, take shelter under a table or bed rather than going out into the open. If you have time, draw the shades and blinds to keep out most of the heat from the blast. Only those people in the direct line of sight of thermal emission will be burn casualties; that is, anything that casts a shadow will afford protection. Tunnels, storm drains, and subways can also provide effective shelter.

In the event of a surprise attack, no matter where you are—out in the open on the deck of a ship, in a ship compartment, out in the open ashore, or inside a building—drop to a prone position in a doorway or against a bulkhead or wall. If you have a protective mask with you, put it on. Otherwise, hold or tie a handkerchief over your mouth and nose. Cover yourself with anything at hand, being especially sure to cover the exposed portions of the skin, such as the face, neck, and hands. If this can be done within a second of seeing the bright light of a nuclear explosion, some of the heat radiation may be avoided. Ducking under a table, desk, or bench indoors, or into a trench, ditch, or vehicle outdoors, with the face away from the light, will provide added protection.

Treatment of Nuclear Casualties

Most injuries resulting from the detonation of a nuclear device are likely to be mechanical wounds resulting from collapsing buildings and flying debris, and burns caused by heat and light liberated at the time of detonation.

A burn is a burn, regardless of whether it is caused by a nuclear explosion or by napalm, and its management remains the same. This is also true of fractures, lacerations, mechanical injuries, and shock. In none of these is the treatment dictated by the cause. For most of the conventional injuries, standard first-aid procedures should be followed.

The following word of caution should be considered when you are treating wounds and burns: Dressings for wounds and burns should follow a closed-dressed principle, with application of an adequate sterile dressing using aseptic techniques. Make no attempt to close the wound, regardless of its size, unless authorized by a physician. If signs of infection and fever develop, give antibiotics. When a physician is not available to direct treatment, the Corpsman should select an antibiotic on the basis of availability and appropriateness, and administer **three times** the recommended amount. If the antibiotic does not control the fever, switch to another. If the fever recurs, switch to still another. Overwhelming infection can develop rapidly in the patients due to burns or damage from radiation. Whenever a broad-spectrum antibiotic is given, administer oral antifungal agents.

To date, there is no specific therapy for injuries produced by lethal or sublethal doses of ionizing radiation. This does not mean that all treatment is futile. Good nursing care and aseptic control of all procedures is a must. Casualties should get plenty of rest, light sedation if they are restless or anxious, and a bland, nonresidue diet.

DECONTAMINATION

If you suspect that you are contaminated, or if detection equipment indicates you are, report to a personnel decontamination facility as soon as possible.

Facilities

In a large-scale nuclear catastrophe, there may be numerous casualties suffering not only from mechanical injuries and thermal burns, but from radiation injuries and psychological reactions as well. The medical facility should consist of a personnel monitoring station, both clean and contaminated emergency treatment stations, a decontamination station, a sorting station, and various treatment stations. It should be set up so that personnel must pass through a monitoring station prior to sorting for medical care. If there is a need for decontamination, the casualty should be routed through the decontamination station on the way to the sorting station. The physical layout should be arranged so that no casualty can bypass the monitoring station and go directly to a treatment station. Also, casualties who are contaminated should be unable to enter clean areas without first passing through a decontamination station. The medical facility flow chart shown in figure 8-3 illustrates an appropriate schema for handling those exposed to nuclear radiation.

TEAMS.—Patients brought in by the rescue teams or arriving on their own should first proceed through the monitoring station to determine whether or not they are contaminated with radioactive material. No medical treatment should be instituted in the monitoring station. Only personnel who have had training and experience as members of Radiological Safety/Decontamination teams or as members of Damage Control parties should be assigned to the monitoring station. Those operating the monitoring station should have a basic knowledge of and experience with radiac instruments. Of the personnel available to the treatment facility, several of those most experienced and knowledgeable in radiological safety and radiation protection should be assigned supervisory jobs in the decontamination station. Also, it is highly desirable to have some personnel with operating room experience to decontaminate patients with traumatic injuries. It is not necessary for the other personnel working in the decontamination station to have any appreciable training or experience other than that given when the medical facility is put into operation.

MONITORS.—After the patients are monitored, they are directed or taken down one of four avenues, depending upon their physical conditions. Those requiring immediate lifesaving measures should be considered contaminated and routed directly through the monitoring station to the contaminated emergency treatment station. Definitive monitoring for these individuals may be performed at the decontamination station. Both treatment stations are set up much the same and should have only those facilities necessary for immediate lifesaving forms of treatment. Personnel working in these stations should be better versed in emergency first-aid care than those used for monitoring and for rescue teams, but they need not be trained in radiation monitoring.

SORTING.—After emergency lifesaving procedures have been attended to, casualties from the clean emergency treatment station should be taken directly to the sorting station, and those from the contaminated treatment station should be taken to the decontamination station. Casualties not requiring immediate emergency treatment should be taken or sent from the monitoring station directly to the sorting station or to the decontamination station, whichever is appropriate. The decontamination station should be set up to take, hold, and dispose of all contaminated clothing and to supply clean replacement clothing after the casualty has been decontaminated. Monitoring equipment will also be required, as will showering and washing facilities, and some capability for surgical (e.g., wound) decontamination when necessary.

Cleaning

Early removal of radioactive "contamination" will reduce radiation burns, radiation dosage, and the chances of inhaling or ingesting radioactive material. There are two rules to be remembered in the removal of radioactive contamination:

- Contamination is easily spread, so "spot" cleaning must be attended to before general decontamination procedures are started.
- Removal of radioactive contamination is best accomplished with soap and water.

SPOT CLEANING.—Cotton swabs or gauze may be used to decontaminate moist areas. Use gummed tapes to decontaminate dry areas. If, after the first cleansing, decontamination is inadequate, the process should be repeated three to five times. If contamination persists, a preparation consisting of a mixture of 50 percent detergent and 50 percent cornmeal, with enough water added to make a paste, should be tried. The contaminated area should be scrubbed (preferably with a soft-bristle surgical brush) for 5 minutes, then rinsed.

GENERAL CLEANING.—After the hot spots have been removed, the second step is to shower with soap and water. Scrub the entire body, including the hair and nails. After the shower, monitor again; if any contamination remains, repeat spot cleaning and shower procedures. If the hair is contaminated, shampoo it several times. If it becomes apparent that shampooing has not removed the radioactive material, cut the hair as close to the scalp as necessary to remove the radioactive material.

If areas become tender from excessive washing, it may be necessary to restore some of the skin oils by gently rubbing in a small amount of lanolin or ordinary hand or face cream. This will soothe the skin and prepare it for further decontamination if additional steps are necessary. Decontamination should be continued until the radioactivity has been reduced to the "safe" level set by the responsible Medical Department representative. Wounds or body parts that resist decontamination may have to be covered and the patient referred to a higher-level medical treatment facility.

UNCONTAMINATED AREAS.—Protect any uncontaminated cut, scratch, or wound with an impermeable tape or other suitable material while decontaminating the rest of the body. If a wound is already contaminated, the simplest and least drastic decontamination method available should be tried first, always by trained medical personnel. First, the wound should be carefully bathed or flushed with sterile water, and a reasonable amount of bleeding should be encouraged. Following decontamination, standard triage procedures are used.

Additional information pertaining to the initial management of irradiated or radioactively contaminated individuals may be obtained from the current version of BUMEDINST 6470.10, *Initial Management of Irradiated or Radioactively Contaminated Personnel.*

Contaminated Material and Supplies

Radiological material may be removed but not destroyed. Water then becomes a special problem. Distillation frees water of radioactive material, providing emergency drinking water. Water coming from an underground source usually is free from radioactive materials and is therefore usable; however, water coming from a reservoir that has to depend upon a surface watershed for its source may not be usable. Fortunately, regular water-treatment processes that include coagulation, sedimentation, and filtration will remove most fallout material, and if the reservoir water can be properly treated, it will be usable again. But for safety's sake, never drink untested water.

SUPPLIES AND FOOD.—Supplies and food can be protected from residual radiation by storage in dust-proof containers. Although the outside of the containers may become contaminated, most of this radioactive material can be removed by washing. The container can then be opened and the contents removed and used without fear of causing significant contamination.

The outer wrappings on medical supplies and the peelings on fruit and vegetables also afford protection to their contents. After carefully removing the outer coverings and checking the contents, it may be found that these materials will be safe to use.

CLOTHING.—Contaminated clothing should be handled with care. Such clothing should never be casually placed on furniture, hung on walls, or dropped on floors, but, instead, should be stored in garbage cans or disposable containers. If these are not available, contaminated clothing should be placed on pieces of paper large enough to be rolled and secured. Grossly contaminated clothing should be properly disposed of by an authorized method, such as burial at sea or in deep pits or trenches, whichever is appropriate. If clothing is in short supply, lightly contaminated clothing may be salvaged by special laundering. Three washings in hot water with detergent should be sufficient. To be sure that this procedure has freed the clothing from radioactive material, each article should be monitored before it is released for reuse. Rubber and plastic materials are readily decontaminated in a warm detergent wash.

SUMMARY

In this chapter we discussed the recognition and treatment of chemical, biological, and radiological (CBR) hazards, and the Medical Department's role in meeting the medical aspects of CBR defense. These included protection from CBR hazards, mass-casualty decontamination, decontamination stations, and supplies for decontamination.